COST AND SAFETY EFFECTIVENESS
OF HIGHWAY DESIGN ELEMENTS

NCHRP Project 3-25

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ABSTRACT

This paper summarizes the anticipated findings from NCHRP Project 3-25, "Cost and Safety Effectiveness of Highway Design Elements." Because the research is still under way, all information contained in this paper is pre-liminary and subject to change. The objectives of this project are: (1) to quantify the effect of varying the magnitude, size, or dimension of each roadway and roadside design element (and/or combination of elements where they are interactive) on accident frequency and severity; and (2) to develop methodology to measure the cost-effectiveness of the various levels of each element. Design elements selected for detailed study include lane width, shoulder width, and shoulder surface type. Accident relationships for each design element are being developed and incorporated into a cost-effectiveness methodology for highway design. Major attention is given to rural two-lane facilities.

Acknowledgment

Disclaimer

INTRODUCTION

The need for this research, as determined by the Project Panel, is as follows:

"To maximize accident reduction with the limited available funds, design standards should be flexible. The design should be tailored for each project, route segment, or subsystem to produce significant accident reductions per dollar expended. In this fashion, the cumulative accident reduction of many such improvements will greatly exceed the reduction possible from a relatively few improvements designed according to a rigid set of high standards that ignore costs.

"Currently available data provide gross measures of the over-all safety and service benefits of highway facilities. However, the data are limited or lacking to evaluate the standards for specific situations and design elements in terms of accident frequency and severity. What is needed is an optimization of geometric design standards for highway facilities, both urban and rural, that reflects a regard for economy without sacrificing traffic safety. Such standards could be applied to the upgrading of existing highways, which will constitute the bulk of the highway construction program in the foreseeable future.

"The general objectives are: (1) to quantify the effect of varying the magnitude, size, or dimension of each roadway and roadside design element (and/ or combination of elements where they are interactive) on accident frequency and severity; and (2) to develop a methodology to measure the cost-effectiveness of the various levels of each element."

Because of the large number of variables involved in the geometric cross section, longitudinal design, and environmental and traffic factors, it was realized that all possible factors and combinations of factors cannot be considered within the time and funding constraints for this project. Therefore, an exploratory Phase I effort was made to identify those areas that offer promise as the most fruitful to pursue in more detail. The probable effect of various design elements on accidents and costs was assessed, and those with greatest promise were recommended for further study in Phase II.

The Phase I effort has been completed, and work is under way on Phase II, which consists of the following two tasks:

1. Quantify the effect on accident frequency and severity for the selected design elements.
2. Develop methodology for, and examples of, cost-effectiveness analyses.

Before discussing the preliminary research findings, I want to emphasize that the primary objective of this project is aimed at reducing costs, not accidents. There is certainly no intent to increase accidents; rather, the goal is to identify situations in which lower design levels can be utilized without adversely affecting safety. In effect, the purpose is to minimize costs that are in excess of those required from an operational and safety viewpoint. This cost-versus-safety distinction is important, because if reducing

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accidents were the primary objective of this research the approach would have been quite different. Nonetheless, improved safety should result because the money that is saved by not building to excessively high standards can be used for additional improvements to other highways for which funds may not otherwise have been available.

FINDINGS - PHASE I

In Phase I about 50 design features were found to have some type of safety relationship with one or more of nine different categories of highway facilities. The gross assessment narrowed this list down to ten design features that had significant potential for cost savings.

The purpose of the gross assessment was to provide a basis for selecting those design elements and features that have the greatest potential for reduction of improvement costs without an adverse effect on safety. The gross assessment established relative priorities of significance for the design features.

The term "gross" should be clearly understood. Decisions on alternative design practices were investigated that reflected probable <u>ranges</u> of geometric configurations, <u>ranges</u> of improvement cost increments, and <u>ranges</u> of effect on traffic safety--all under the general conditions of typical improvement projects. The best available sources of information were used for estimating changes in costs and changes in accident rates. Nevertheless, the findings must be recognized as a gross assessment, without the precision that might be expected from analysis of a specific individual project. The findings are valid from the standpoint of establishing a relative ranking of the most significant study areas.

The gross assessment involved separate evaluations by highway facilities and design element features. In some instances, quantitative values were developed and this facilitated the priority ranking. For other design features, quantitative measures could not be established and it was necessary to use judgment in ranking.

Figure 1 summarizes the relative ranking of the design element features by highway facilities according to the three identified priority groups.

Many design features, very important to highway safety, have not been included in the listing. This should not be construed as downgrading their safety impacts; rather, it indicates that these features have less potential for significant cost savings in a cost-effectiveness approach to highway design.

Several factors were considered for establishing priority ranking among types of highway facilities in terms of potential cost-effectiveness improvement in safety-related design features. For each type of facility, the following information was summarized:

> Future highway improvement needs.
> Total mileage.

FIGURE 1

RANKING OF DESIGN ELEMENT FEATURES
BY PRIORITY GROUPS

DESIGN ELEMENT FEATURE	RURAL HIGHWAYS				URBAN HIGHWAYS			STRUCTURES AND BRIDGES
	TWO-LANE	FOUR-LANE UNDIVIDED	FOUR-LANE DIVIDED	FREEWAY	2,4 and 6 LANE UNDIVIDED ARTERIAL	4 and 6 LANE DIVIDED ARTERIAL	FREEWAY	
Lane width	1	1	1	3	1	1	2	2
Shoulder width	1	1	1	3	1	1	2	2
Shoulder surface type	1	1	1	3	1	1	2	
Median width	N.A.	N.A.	2	3	N.A.	2	3	
Median type	N.A.	N.A.	2	3	N.A.	2	3	
Median barrier type	N.A.	N.A.	2	3	N.A.	2	3	
Horizontal curvature	2	2	2	3			3	3
Sight distance	2	2	2	3			3	3
Access control	2	2	2	N.A.	2	2	N.A.	
Roadside slope	2	2	2	3	2	2	3	
Ditches	2	2	2	3			2	
Guardrail	2	2	2	3			2	
Auxiliary lane	3	3	3	3	3	3	3	
Fixed objects	3	3	3	3	3	3	3	3
Barriers	3	3	3	3	3	3	3	3
Frontage roads				3	3	3	3	
Lighting					3	3	3	3
Drainage inlets/outlets roadside	3	3		3			3	

PRIORITY GROUPS

(1) Design element features that show the highest potential for cost savings without a commensurate loss in safety effectiveness.

(2) Design element features that show good potential for cost savings without a commensurate loss in safety effectiveness.

(3) Design element features that exhibit less potential for cost savings.

Daily vehicle-miles.
Average daily number of vehicles.
Accident rates.

The 1972 National Highway Needs Report and the 1974 National Transportation Plan provided sources of information for the first four items. These data are summarized in Figure 2. The particular significance of two-lane rural highways stands out clearly. They constitute more than 86 percent of the total mileage, carry almost 39 percent of the traffic, and the estimated future improvement needs amount to about 46 percent of the total.

Vehicle-miles, and particularly the average daily number of vehicles, are measures of the gross and average vehicular exposure on the highway system. Exposure is a very critical factor in cost-effectiveness, cost-benefit, and cost-safety-effectiveness analyses. In general, expensive improvements (high standards) on low-volume facilities in the name of safety and efficient operation are less justifiable than on higher-volume facilities. On this basis, it was found that rural two-lane highways exhibited by far the greatest potential for cost savings, followed by urban arterials, multilane rural highways, freeways, and structures.

Review of the literature and research confirmed that for some design features the upper-level increments of commonly used geometric design provided little if any increased safety effectiveness. Lane width and shoulder width both fell in this category, and it was found that variations in either had a significant impact on total project costs.

Of the 50 design features reviewed in Phase I, the researchers recommended three for detailed analysis in Phase II--lane width, shoulder width, and shoulder surface type. At the request of the Project Panel, median barrier type and total roadway width were added to the list. Clear roadside area was considered to be another prime candidate; however, the unavailability of analysis data precluded studying this feature. An FHWA research study, being conducted by Calspan Corporation, is investigating the safety characteristics of clear roadside area.

Phase 2 of this study will provide a basic methodology for evaluations to guide decisions on these safety-related design features and will establish quantitative criteria for a few key design features to assist designers in initiating cost-effectiveness evaluations. The desired end-product of the research is a user's manual that contains the cost-effectiveness methodology for design, including as much information that is available on the cost-accident relationships.

Before discussing the Phase II findings, I want to emphasize that the research is still under way and that much of what follows is very preliminary and undoubtedly will be changed. The purpose of this discussion is simply to show you the type of information that is being developed. Several figures are provided for illustration of the anticipated results and are not based on actual study findings.

FIGURE 2

ANALYSIS OF RELATED DATA FOR HIGHWAY FACILITIES [1]

	Percent of Total			
	Highway Needs	Mileage	Daily Vehicle Miles	Average No. of Daily Vehicles
Freeways, including Interstate	11.0	3.9	23.5	12,619
Multilane Divided Rural Highways	4.3	1.2	2.2	3,770
Multilane Undivided Rural Highways	2.2	0.5	0.9	3,770
Two-lane Rural Highways	46.3	86.3	38.6	938
Urban Arterials	36.2	8.1	34.8	8,989
	100.0	100.0	100.0	

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[1] Excludes local roads and urban non-arterial systems

SOURCE: (90) U. S. Department of Transportation "Part II of the 1972 National Highway Needs Report," April 1972.

(91) U. S. Department of Transportation "1974 National Highway Transportation Plan," July 1975.

Figure 3 shows a draft outline of the user's manual. The remainder of this paper is limited to the "accident relationships" portion of Chapter 2 and the economic analysis described in Chapter 6. These two areas contain most of the original research conducted in NCHRP Project 3-25 and, therefore, constitute the most significant findings. Nonetheless, it should be recognized that the manual will contain a complete description of the total design process, including the new findings and previous research.

Safety-Design Relationships. One of the key ingredients to the cost-effectiveness analysis is a set of relationships that will enable the designer to estimate accident rates for each alternative under consideration. Alternatives in this study consist of different combinations of geometric design elements rather than alternative locations.

Many safety-design relationships have been developed in previous research efforts, and these are being incorporated into the current work. In addition, new relationships are being developed based on original accident data and geometric design records. Accident and highway geometric files are being used from Maryland, Washington, and New York. These separate files were merged into a composite accident-geometric data base file for each state. A combined Maryland-Washington file was also prepared.

Statistical analyses and data summaries have been restricted to rural two-lane due to project resources and the availability of adequate data bases for the other highway facilities. The following discussion of safety-design relationships is directed toward rural two-lane highways.

The design elements for which safety relationships were investigated included lane width, shoulder width, and shoulder surface type. Other design characteristics, such as ADT group and horizontal curvature were used as variables to stratify development of the safety-design relationships.

The following information was obtained for various combinations of traffic volume groups, horizontal curvature, pavement width, shoulder width, and shoulder surface type:

> Accident Rate
> Number of roadway sections
> Accident rate standard deviation
> Upper confidence interval for accident rate
> Lower confidence interval for accident rate
> Property Damage Only (PDO) Fraction
> Standard Deviation of PDOF
> Total accidents
> Total miles
> Total vehicle miles

One of the first tests made of these data summaries was to determine whether or not they were in general accord with previous research findings and more importantly whether the trends and indications were reasonable. Figure 4 illustrates the generally decreasing accident rate for increasing traffic volume groups. These preliminary findings are in

FIGURE 3

NCHRP 3-25 USERS' MANUAL

CONTENTS

ILLUSTRATIVE ACCIDENT RATES
LESS THEN 3° CURVATURE
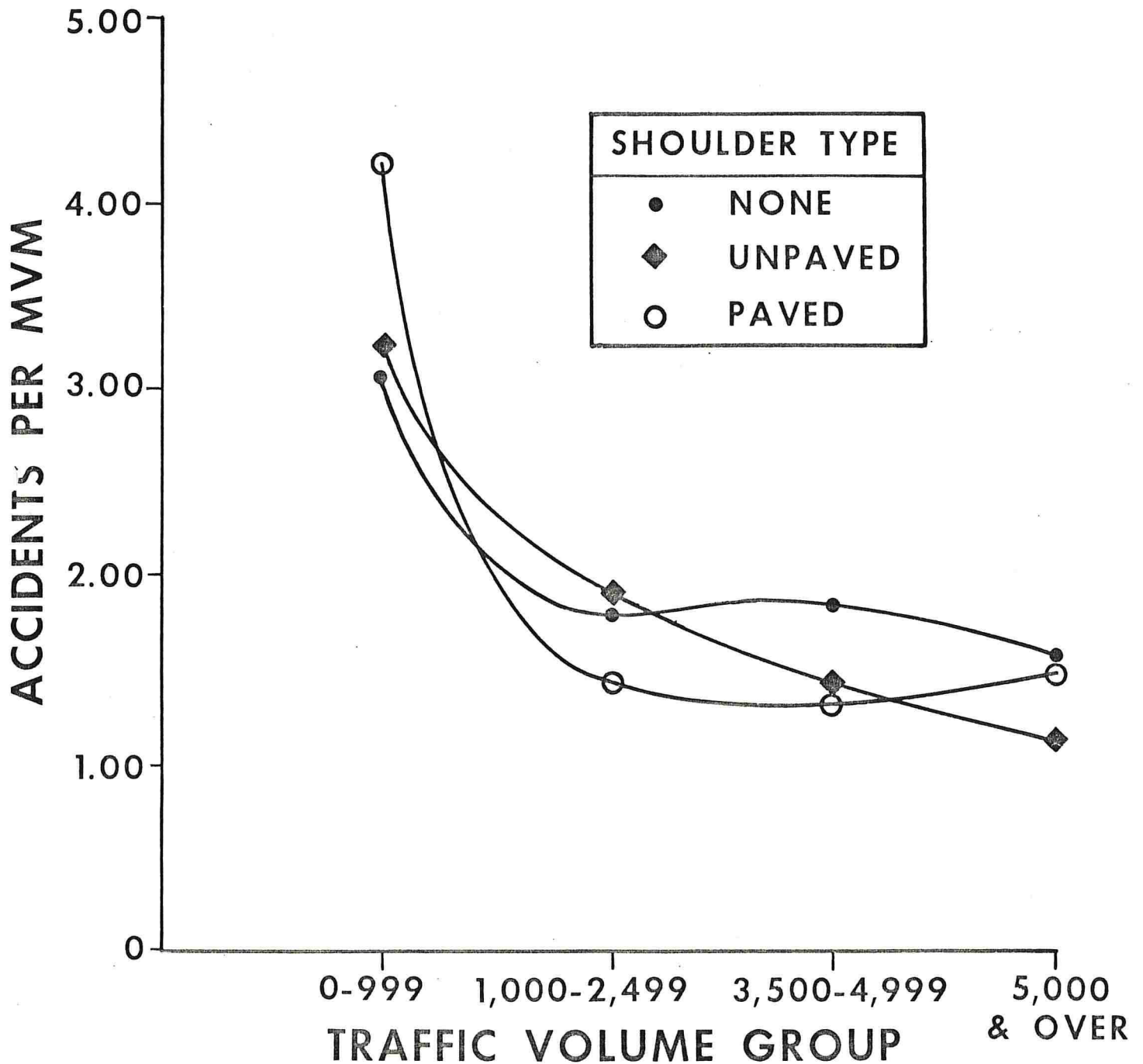## ALL PAVEMENT AND SHOULDER WIDTHS

FIGURE 4

agreement with other research efforts in this area. From a logical viewpoint they also appear to be reasonable, since roadways with higher traffic volumes frequently have wider lane widths, wider shoulders and also paved shoulders --design features associated with safer roads. Figure 5 shows the same relationships for highway sections with pavement width of 24-ft and 10-ft shoulders. Curves for the other combinations of design elements are also being developed.

Several steps are required in order that the results and methodology can be utilized by all highway design agencies--not just the three states whose data were used for this anlaysis. These steps include:

1. Establish base accident rates--for roadway sections having pavement and shoulder geometrics for a maximum design--24-ft pavement with 10-ft shoulders.
2. Determine the percent increase in accident rate for incremental reductions in pavement and shoulder geometrics.
3. Determine percent of property damage only (PDO) accidents--for accounting for accident severities--by the incremental geometrics.

Step 1 must be accomplished by each state as part of the cost-safety design process. Steps 2 and 3 will provide quantification of the safety effect of reducing the pavement and shoulder geometrics.

The percent accident rate increase is calculated for each combination of pavement width and shoulder width as shown in Table 1. A separate table such as this will be developed for each ADT group, degree of horizontal curvature and shoulder surface type. These percent increase figures, as determined from the data of the three study states, are to be applied to a base rate calculated by the individual state using their own accident data. This approach was selected because of the variation in accident rates among states. Figure 6 shows a plot of the percent increase values for illustrative purposes.

Economic Analysis. The cost-effectiveness analysis is limited to a comparison of accident and construction costs. In effect, the analysis identifies the design or alternative for which additional construction costs are not justified for the purpose of reducing accident costs. The alternative so identified may or may not be appropriate for actual construction, depending on operational factors, consistency of design considerations, etc. The contribution this analysis offers is that the designer can avoid selecting a higher design for strictly safety reasons unless the higher design is truly cost-effective.

To illustrate the cost-effectiveness analysis, the following example is provided. First, the design project must be broken down into homogeneous design sections. That is, any change in characteristic that affect the selection of the design features being considered--lane width, shoulder width, and shoulder surface type--mandates that a new section be established. For rural two-lane highways these characteristics are ADT group and degree of curvature. Next, the designer should limit the number of alternatives to those that are practical and feasible. For example, 12-ft lanes with no shoulders may not be a practical design; similarly for 10-ft lanes with 10-ft paved shoulders. By eliminating such alternatives, the number of designs for which construction and accident costs must be calculated can be reduced considerably.

ILLUSTRATIVE BASE
ACCIDENT RATES

LESS THEN 3° CURVATURE
24 FOOT PAVEMENT AND 10 FOOT SHOULDERS
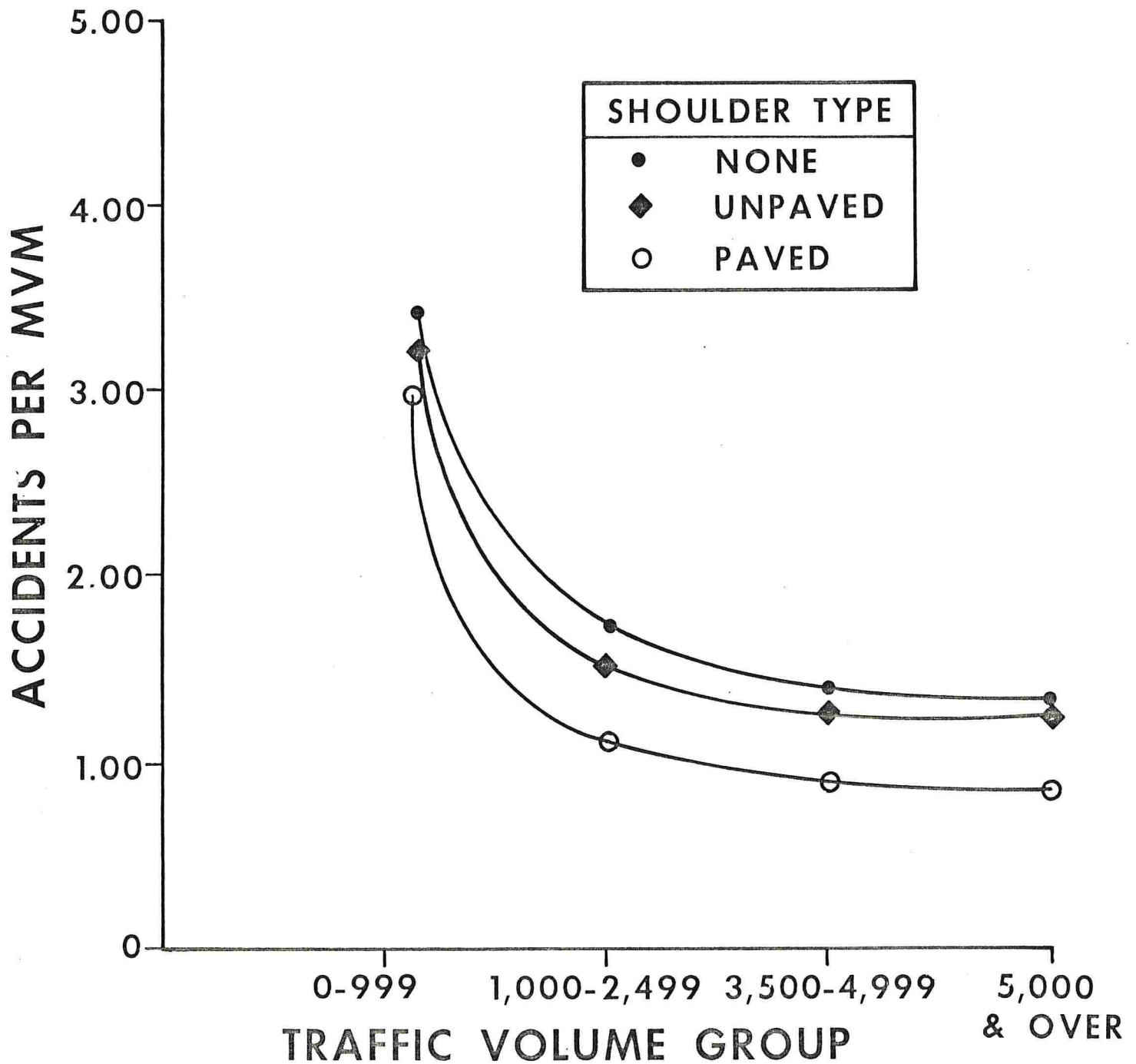
FIGURE 5

ILLUSTRATIVE PERCENT ACCIDENT RATE INCREASE
2,500—4,999 ADT
LESS THEN 3° CURVTURE

UNPAVED SHOULDER WIDTH (FT.)	PAVEMENT WIDTH (FT.)			
	18 or LESS	20	22	24
0	130	120	115	105
1—2	102	95	70	64
3—4	84	75	46	40
5—6	68	55	28	20
7—8	50	40	15	8
9—10	42	35	10	0

TABLE 1

ILLUSTRATIVE PERCENT ACCIDENT RATE INCREASE
2,500–4,999 ADT
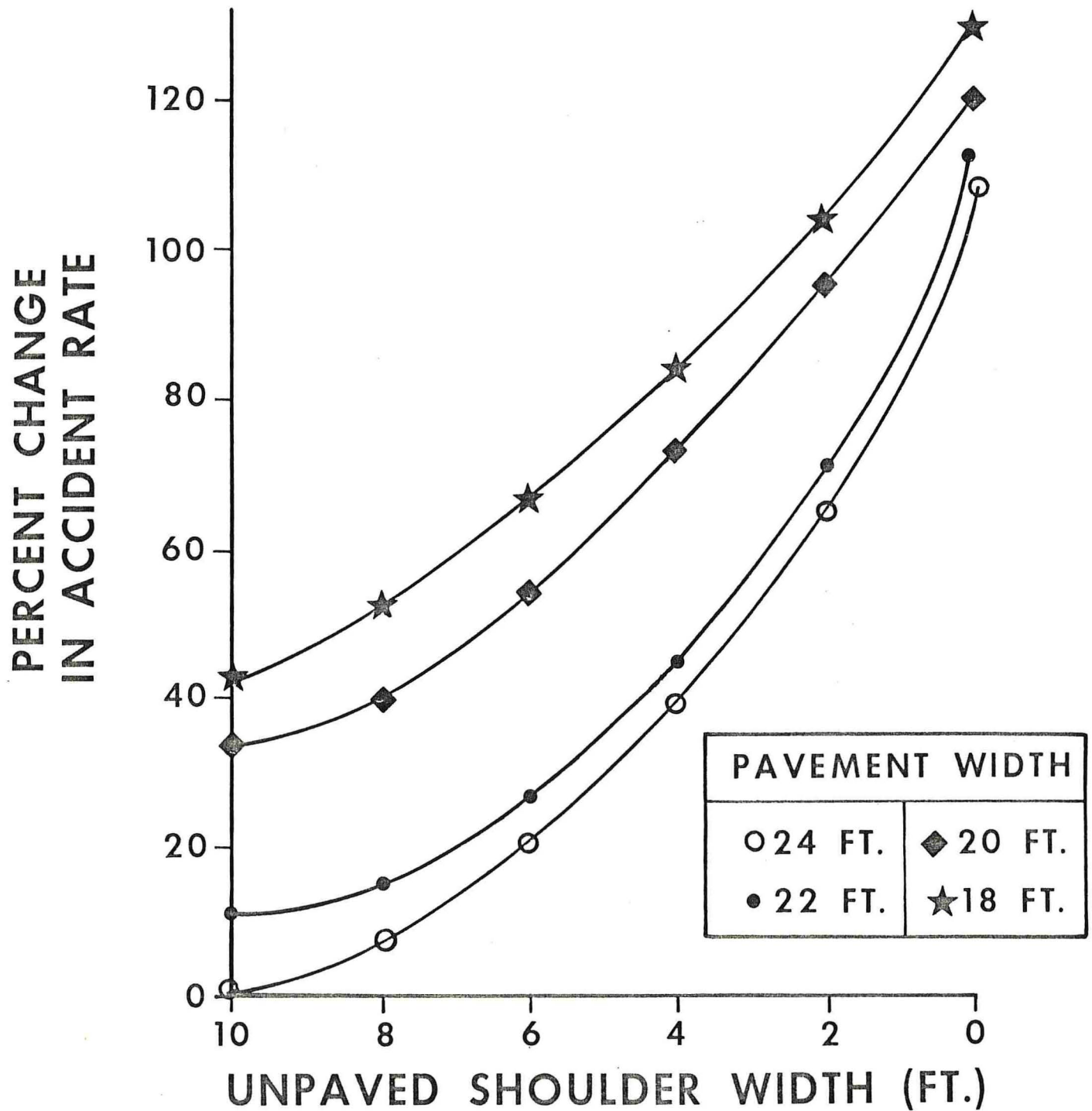## LESS THEN 3° CURVATURE

FIGURE 6

Each alternative design, or combination of lane width, shoulder width, and shoulder surface type selected must have the respective construction costs and associated accident costs calculated.

Table 2 gives a group of 18 alternatives for the sections of a 2-lane rural highway project with curvature of 3° or less. The same project has another group of alternatives for sections with curvature of less than 3°.

The construction and accident costs have been calculated for each alternative. This is an example of the basic data for use in selecting the most cost-safety effective design for this specific project.

The analysis of cost data must be performed separately for each group of homogeneous sections within the project limits. The following steps are to be performed for each homogeneous group:

Step 1. Rearrange the order of the subset of alternatives into smallest segment construction cost first. This has been done in Table 3. Note that the original ordering (Table 2) was not according to ascending cost even though lane width and shoulder width generally increase. Further, an ascending construction cost does not necessarily lead to a decreasing accident cost.

Step 2. Determine the disposition of any alternatives with both increasing construction cost and increasing accident cost. Because an increase in construction costs accompanied by an increase in accident costs could not possibly be a cost-safety effective design, these alternatives should be eliminated from further analysis.

Step 3. Assign reference numbers to the remaining alternatives in the segment so that the resultant list will be in decreasing order by accident cost. Any inconsistent alternatives in this regard will not be assigned reference numbers, as indicated in Table 3 by an asterisk.

Step 4. Repeat Steps 1 through 3 for all homogeneous sections and prepare a table, such as shown in Table 4. Each group of homogeneous sections for a typical project is shown here for ease of cross reference. Note that the "less-than-3°" alternatives come directly from Table 3.

After these steps are completed, a minimum and maximum total project cost can be established by summing the low and high construction costs for each homogeneous group. Table 5 presents the results of these calculations for construction costs ranging from $143,170 to $318,070 in increments of $25,000. The first column lists the segment group (0-3 degrees, +3 degrees). The second column lists the alternative number (ALT-NUM) that is the safest design for a given expenditure of funds. This is the reference number, which can be referenced back to the actual design specifications. For example, the 3 for 0-3 degree segments shows that the design specifications for this segment (from Table 4) are 10-ft lane width and 8-ft unpaved shoulders. The last two columns show the construction and accident costs for the alternative. The sum of the accident costs and the sum of the construction costs are given at the bottom of these columns. The accident costs are the lowest that can be obtained for the fixed expenditure of funds.

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Table 2　Example Subset of Alternative Designs

2-Lane Rural Highways
Segments Less Than 3 Degree Curvature

Lane Width	Shoulder Width	Shoulder Surface Type	Construction Cost	Accident Cost
10	4	Paved	$110,390	$159,021
		Unpaved	102,270	163,021
	6	Paved	121,380	145,946
		Unpaved	106,190	150,256
	8	Paved	129,500	132,439
		Unpaved	109,130	136,828
11	4	Paved	156,870	143,785
		Unpaved	148,750	147,215
	8	Paved	167,860	128,945
		Unpaved	152,670	132,752
	10	Paved	175,980	114,264
		Unpaved	155,610	118,051
12	4	Paved	207,060	128,347
		Unpaved	198,940	131,409
	8	Paved	218,050	111,944
		Unpaved	202,860	115,249
	10	Paved	227,170	96,089
		Unpaved	205,800	99,274

Table 3   Example Subset of Alternatives Arranged by
Lowest Construction Cost First
Segments Less Than 3 Degree Curvature

Lane Width	Shoulder Width	Shoulder Surface Type	Segment Cost	Accident Cost	Reference Number
10	4	Unpaved	102,270	163,021	1
	6	Unpaved	106,190	150,256	2
	8	Unpaved	109,130	136,828	3
	4	Paved	110,390	159,222	*
	6	Paved	121,380	145,946	*
	8	Paved	129,500	132,439	4
11	4	Unpaved	148,750	147,215	*
	8	Unpaved	152,670	132,752	*
	10	Unpaved	155,610	118,051	5
	4	Paved	156,870	143,785	*
	8	Paved	167,860	128,945	*
	10	Paved	175,980	114,264	6
12	4	Unpaved	198,940	131,409	*
	8	Unpaved	202,860	115,249	*
	10	Unpaved	205,800	99,274	7
	4	Paved	207,060	128,347	*
	8	Paved	218,050	111,944	*
	10	Paved	227,170	96,089	8

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* Eliminated from further analysis due to increasing accident costs.

Table 4   Example Data Costs for Project Sections
2-Lane Rural Highways

Reference No.	Design Features			Costs	
	Lane Width	Shoulder Width	Shoulder Surface	Construction	Accident
Less Than 3 Degrees					
1	10	4	Unpaved	$102,270	$163,021
2	10	6	Unpaved	106,190	150,256
3	10	8	Unpaved	109,130	136,828
4	10	8	Paved	129,500	132,439
5	11	10	Unpaved	155,610	118,051
6	11	10	Paved	175,980	114,264
7	12	10	Unpaved	205,800	99,274
8	12	10	Paved	227,170	96,089
+3 DEGREES					
1	10	4	Unpaved	40,900	65,200
2	11	6	Unpaved	42,500	60,100
3	11	10	Unpaved	51,800	52,980
4	11	8	Paved	62,250	47,200
5	12	10	Unpaved	82,300	39,700
6	12	10	Paved	90,900	38,400

Table 5 Allocation of Construction Costs

Segment	ALT-NUM	Construction Cost	Accident Cost
0 - 3 Degrees	1	$102,270	$163,021
+3 Degrees	1	40,900	65,200
TOTAL COSTS		$143,170	$228,221

$170,000 ALLOCATION

Segment	ALT-NUM	Construction Cost	Accident Cost
0 - 3 Degrees	3	$109,130	$136,828
+3 Degrees	3	51,800	52,980
TOTAL COSTS		$160,930	$189,808

$195,000 ALLOCATION

Segment	ALT-NUM	Construction Cost	Accident Cost
0 - 3 Degrees	3	$109,130	$136,825
+3Degrees	5	82,300	39,700
TOTAL COSTS		$191,430	$176,525

$220,000 ALLOCATION

Segment	ALT-NUM	Construction Cost	Accident Cost
0 - 3 Degrees	5	$155,610	$118,051
+3 Degrees	4	62,250	47,200
TOTAL COSTS		$217,860	$165,251

$318,070 ALLOCATION

Segment	ALT-NUM	Construction Cost	Accident Cost
TOTAL COSTS		$318,070	$134,489

The minimum construction cost of $143,170 should be used as a starting value. For each $25,000 additional construction costs, determine the optimum combination of alternatives to obtain minimum accident costs.

Marginal Benefits. The selection of optimum designs for fixed construction costs, as shown in Table 5, provides all the information necessary to perform both a cost-benefit and marginal cost-benefit analysis. Table 6 summarizes the marginal safety benefits and total safety benefits. The marginal costs constitute the additional construction expenditure, and the marginal safety benefit is the reduction in accident cost when the corresponding construction expenditure is made. The total safety benefit is the cumulative total of the marginal safety benefits.

Figure 7 shows how the accident cost decreases with increasing construction expenditures. As more and more funds are expended, their capability to purchase safety benefits is generally reduced. To illustrate, the first additional $25,000 increment purchases $38,413 additional safety benefits, whereas the last $25,000 increment purchases only $4,485 in benefits. This is shown in Figure 8, where the marginal safety benefits are plotted against each additional $25,000 expenditure for construction.

Total safety benefits are shown in Figure 9. Note that the first $145,000 is not a safety expenditure. It is required to construct the project in its most basic form. From that point on the additional investments are viewed as contributing to the safety benefits.

Selection of Alternative. From the marginal benefits shown in Table 6, it is shown that for an additional $25,000, from the minimum cost of $145,000, an additional $38,413 in safety benefits can be realized. However, if an additional $25,000 is expended, the additional benefit is only $13,283--less than the additional investment.

On the basis of marginal benefits the alternatives specified by the $170,000 expenditure define the lowest-cost design. Expenditures in excess of this amount do not return equivalent benefits. However, because the construction-accident cost tradeoff is so dependent on estimated costs of accidents by severity, it is not recommended that this be the sole criterion for selection of the construction expenditure. Rather, it should be recognized that each of the policies specified are optimal for the corresponding construction expenditure. Judgment must be made at this point in light of alternative uses of funds utilizing similar results of other project analyses.

At this point, the designs for the segment groups must be checked to ensure that the designs specified are practical and reasonable. If the final designs selected by this process are extremely variable and inconsistent, it is the responsibility of the designer to determine the reasons and to take corrective action. Possible reasons include poor input data for costs, errors in quantity estimates for alternatives, misjudgments in the initial selection of alternatives, and others. The final design must represent the agency's highway improvement policy in terms of specific design features, as well as the most cost-safety effective design.

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Table 6   Example Cost-Benefit Data

Total Construction Cost	Total Accident Cost	Marginal Construction Cost	Marginal Safety Benefit	Total Safety Benefit
$145,000	$228,221			
		$25,000		
170,000	189,808		$38,413	$38,413
		$25,000		
195,000	176,525		13,283	51,696
		$25,000		
220,000	165,251		11,274	62,970
295,000	138,974			
		$25,000	4,485	93,732
318,070	134,489			

CONSTRUCTION COSTS
VS
ACCIDENT COSTS

TOTAL ACCIDENT COSTS ($1,000)

225
200
175
150
130

145   170   195   220   245   270   295   320

CONSTRUCTION COSTS
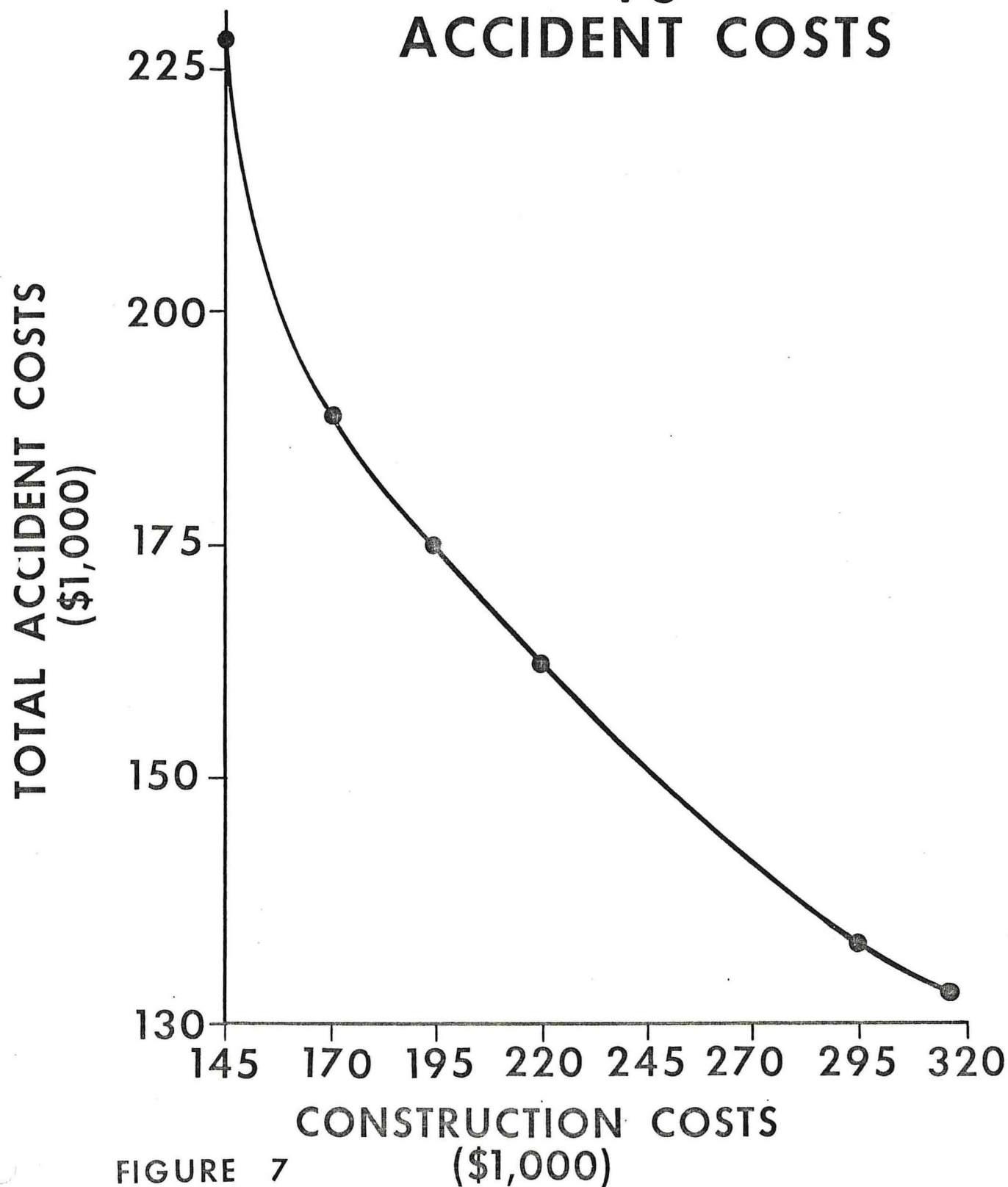($1,000)

FIGURE 7

MARGINAL BENEFITS
VS
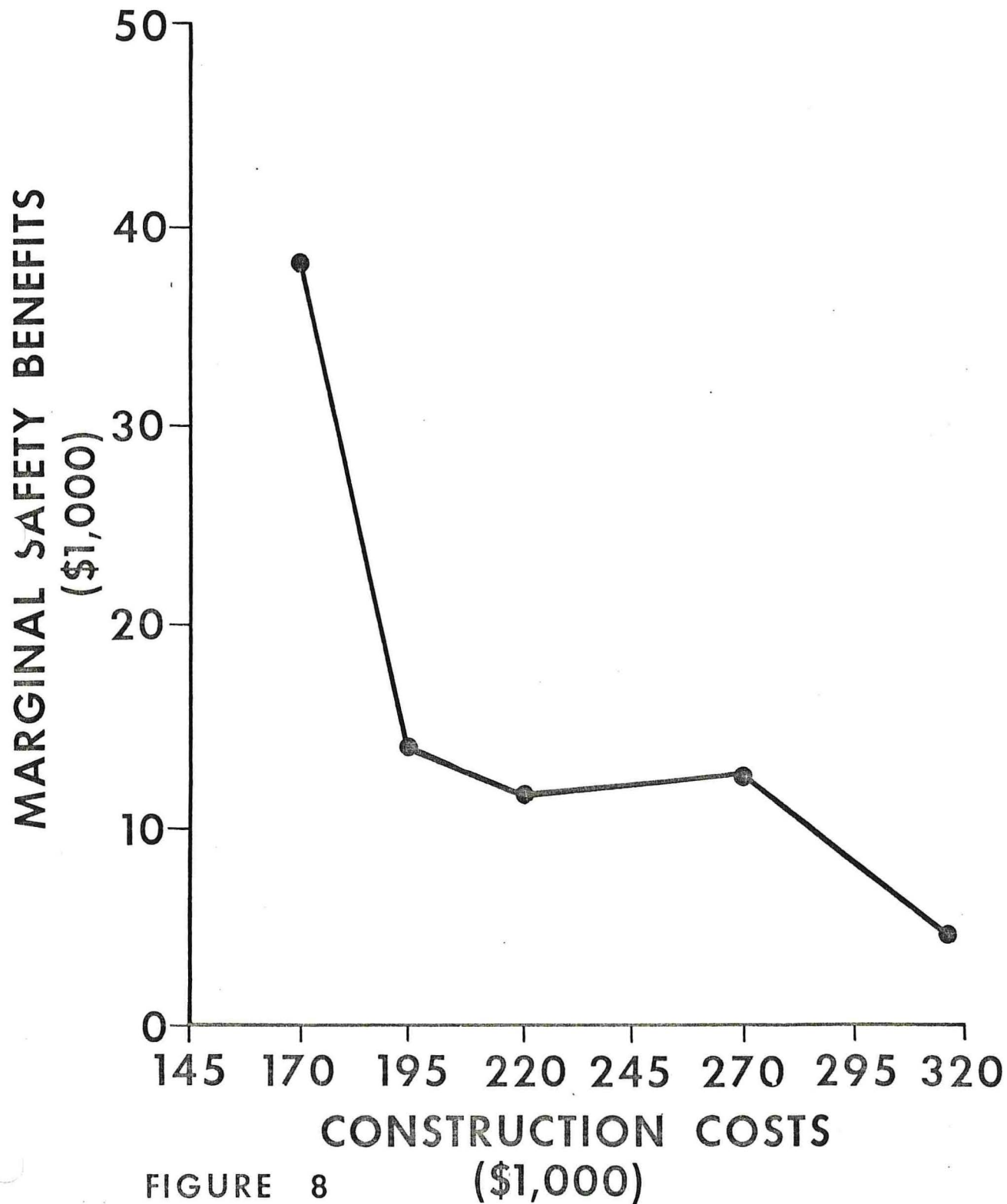# CONSTRUCTION COSTS

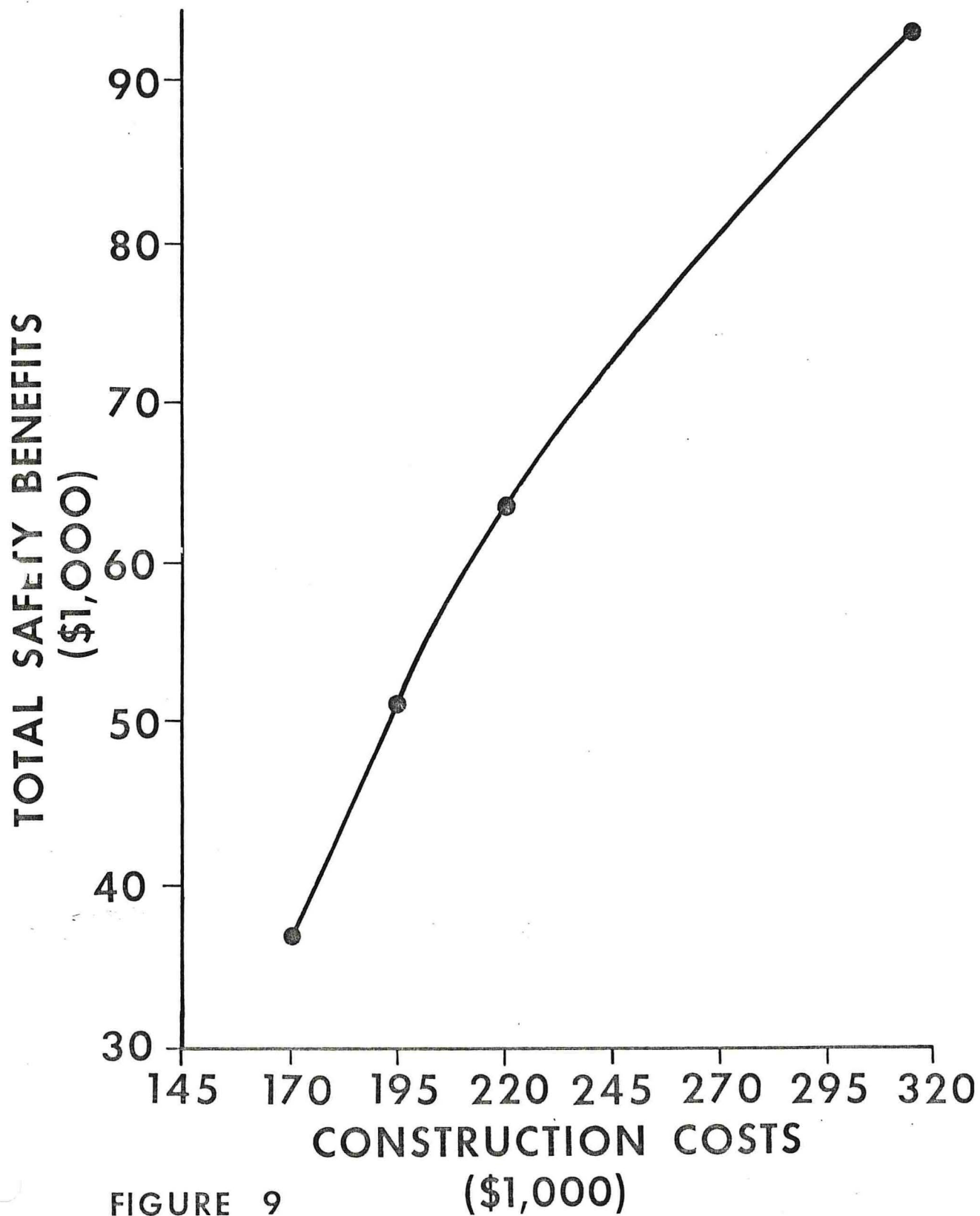FIGURE 8

TOTAL SAFETY BENEFITS

FIGURE 9

APPLICATION OF RESULTS

Specific recommendations and suggestions for application of these findings can not be finalized until the research is completed. Several critical questions still need answers. Are the safety-design relationships conclusive; i.e., do the results prove the safety impact of varying lane width, shoulder width, etc.? Can the cost-effectiveness methodology be incorporated into a state's highway design process? Does the consideration of operational factors and consistency of design overwhelm the safety design considerations?

Some of these questions will be answered by the researchers, some by research critics, and the most important ones by state design engineers. Even if the findings are conclusive, and even if the proposed methodology is sound, there remains a need for a desire and willingness on the part of state design engineers to implement the findings. There is a certain comfort and safety in using rigid design standards rather than assessing and selecting alternative designs for each project. Will the potential for cost savings be adequate to encourage a harder look at cost-safety-operations trade-offs? This is up to the states.

The decision is complicated by numerous factors. Research is seldom totally conclusive; therefore, the designer will need to assess what findings are acceptable for implementation. He must weigh the researcher's recommendations, his own current practices, and acceptability of the findings to other agencies (e.g., FHWA).

At best then, NCHRP Project 3-25 will only provide some hopefully useful input to design decisions, and will not provide a new replacement set of design procedures or a new set of design standards. Nor was it intended to.

The results of the project should provide the potential for significant cost savings if, in fact, a lower design level is determined to be acceptable for a given condition. However, such a determination will not be made without conclusive evidence that it is correct, because the end result from an erroneous conclusion could be an unnecessary reduction in safety.